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INVESTIGATIONS IN THE CONTROL OF THE CYCLAMEN MITE (*TARSONEMUS PALLIDUS* BANKS)

FRANCIS MUNGER[1]

INTRODUCTION

The cyclamen mite (*Tarsonemus pallidus* Banks) is a serious pest, particularly of cyclamen but also of several other important greenhouse plants. In common with other mites it is difficult to control, yet because of the serious damage caused by it, some practical means of suppression or eradication is imperative.

New observations relative to the biology of the cyclamen mite are reported in this bulletin. Methods of control have been tried and suggestions are given for their use.

EARLY RECORDS OF OCCURRENCE

In 1883, H. Garman (13) described a mite infesting verbenas in Illinois. Tho he gave it no name, he saw that it was a new species. Banks (1) described *Tarsonemus pallidus* in 1899 from material collected on chrysanthemums in greenhouses at Jamaica, New York. P. Garman (15) is of the opinion that this is the same species as that collected earlier in Illinois.

Distribution

Commonly known today as the cyclamen mite, the species has a rather wide range in the northern United States. Moznette (21) reports it from Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Maryland, Virginia, Ohio, Illinois, Wisconsin, Iowa, Missouri, Colorado, Oregon, and Washington, and says it occurs also in Ontario. He does not report it from Minnesota.

The Insect Pest Survey Bulletin of the United States Bureau of Entomology adds two records of infestations of the cyclamen mite from Alabama. The pest is also recorded from California and southern Quebec on strawberry, and from Indiana on many greenhouse plants. In 1931 it was reported on delphinium (larkspur) outdoors, in Maryland. McDaniel (19, 20) includes the cyclamen mite among greenhouse insects of Michigan. In Minnesota, the cyclamen mite is common all over the state in greenhouses where its host plants are grown.

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Host Plants

The large variety of plants attacked by the cyclamen mite may cause one to wonder at its being given this name. P. Garman suggested that it would be more properly known as the "pallid mite."

It was apparently reported as attacking verbenas in 1883 (13). It was described from chrysanthemums in greenhouses in 1898. P. Garman found mites outdoors on lindens at College Park, Maryland, that were identical with the female of *Tarsonemus pallidus*. Only females were observed. The writer has seen the cyclamen mite on the Roy and Rose Chochard as well as on several other varieties of chrysanthemum. It occurs also on the White Rock, London Pink, Geneva Pink, and Helen varieties of snapdragon, apparently breeding with some difficulty on the Helen. During the winter of 1928-29 mites were found to infest forget-me-not, African violet, begonia, fuchsia, and sweet pea. They have been reported outdoors on larkspur and strawberry. It should be remembered, however, that the mite *T. fragariae* Zimm. is found on strawberry and might be the cause of misidentifications. H. L. Parten, of the Minnesota Agricultural Experiment Station, has found the pallid mite also on cybodium, moccasin flower, rhododendron, and orchid. P. Garman reported it on geranium. Other workers have observed it on variegated geranium, delphinium, heliotrope, stevia, and daisy. The earliest report of the mite in Canada was published in 1917, when it was found on cyclamen. McDaniel (20) also gives gloxinia and petunia as food plants.

Nature of Injury

The cyclamen seems to be the favorite host plant of this species. Injury to the small seedling consists in a gall-like distortion of the young leaves when the infestation is light. The first leaves may wilt or even be killed when the infestation is heavy. Distortions of the young leaves may be carried by the plant through the entire flowering period. When buds are infested the petals become darkened and distorted and the flowers do not open properly. On begonia, cyclamen, and fuchsia the mites migrate from young leaves to the young flower buds at the leaf axils when the buds begin to develop. An analogous situation is to be found in the peach bud mite (*Tarsonemus waitei* Banks) (23).

There is an apparent correlation between slow growth of the host plant and mite infestation. Cyclamen, the favorite host of the mites, is a slow growing plant. Slow growing snapdragons, such as the White Rock, are more susceptible to mites than those that grow more rapidly. Sometimes, under favorable conditions, White Rock snapdragons may outgrow the mites.

Description

The cyclamen mite belongs to the class Arachnida, which also includes spiders and ticks. It is a member of the family Tarsonemidae of the order Acarina. The Tarsonemidae are characterized as having tracheae, the legs with terminal claws, the body divided into cephalothorax and abdomen. Ventral suckers are lacking. The females have a clavate hair between the first and second legs. The genus *Tarsonemus* is one of two genera belonging to the subfamily Tarsoneminae. The latter group is distinguished from other members of the family by the fact that the hind legs in the female end in long hairs and those of the male are about as long as the third pair. *Tarsonemus* is characterized as having an elongate body, terminal mouthparts, and thickened hind legs in the male. The hind legs of the female have two terminal hairs. Cameron (6) records thirty-three species of this genus, more than twenty of which are definitely injurious to plants of economic importance.

The cyclaman mite is extremely minute. To the unaided eye it resembles a tiny dust particle. In this matter of size there is an error in the original description by Banks (1), the lengths given being 1.1 mm. for the female and 0.75 mm. for the male. Moznette (21) gives the length of the male as 0.180 to 0.185 and of the female as 0.240 to 0.260 mm. Measurements by the writer agree closely with those of Moznette. Ewing, in correspondence, also corroborates, from the type specimens, the measurements of Moznette.

For detailed descriptions, the reader is referred to the original one by Banks (1), to Ewing (10), and others.

Life History and Habits

The most extensive rearings of this mite have been made by P. Garman (14) and by G. F. Moznette (21). Garman found that the minimum time required for an egg to develop to a reproductive female is about 7½ days, the maximum being about 15 days. Eggs are laid at the rate of one to three a day. The total number laid by a single female ranges from twelve to sixteen. The adult stage, according to Garman, may last from 14 to 20 days, tho under favorable conditions they may live much longer. The total number of female descendants from a single egg in the course of a month should be about forty. Moznette found that the cyclamen mite requires 21 to 22 days to develop from egg to adult.

The writer, on October 29, placed a single female on a tiny leaf of cyclamen. On November 27, eleven eggs, nine larvae, six resting individuals, and one adult female were removed from the leaf. No dead females were seen, so it is likely the original female was there and still

alive. In this case the total number of eggs laid by the female in 29 days was twenty-six, an average of slightly less than one a day. The mites cause a distortion of the leaves which make daily observation of development almost impossible. The average maximum temperature in the greenhouse for the 29 days was 78° Fahrenheit, and the average minimum 54.6°.

Some habits of the cyclamen mite are rather unusual. The females are parthenogenetic, that is, they may lay unfertilized eggs. These eggs invariably produce females. Another peculiarity lies in the curious habit of the males, which carry about the female resting stages on their backs. P. Garman (14) believes that fertilization takes place at this time, or at least that the females can be fertilized some time during the resting stage.

The newly hatched larval mite has six legs instead of eight as has the adult. It feeds and grows until finally it assumes a quiescent or resting stage. The adult mite develops within the larval skin at this period. When mounted in glycerin or in Buxton's fluid for microscopical examination the developing legs of the adult may be seen through the transparent larval skin. When the adult mite is about to emerge the hardened larval skin splits transversely across the back. Mating occurs, apparently, soon after emergence. In one instance the writer observed a male carrying a resting individual. It was enclosed with its burden between two hollow glass slides. The next morning the female had emerged and the pair were mating. The fourth pair of legs of the male seem never to be used in crawling but function to grasp the resting female.

The habits of the various mites of the genus *Tarsonemus* are rather widely different. *T. chionaspivorus* Ewing (9) is predaceous on the oyster shell scale on poplar. Other species have been found living in the tracheae of various insects. However, Banks (2) generalizes concerning the genus, saying that they affect "various plants, sometimes producing galls upon them." Gall-like distortions of the plant are produced by the cyclamen mite, *T. pallidus* Banks. "They live in colonies upon the leaf or stem at the base of flowers, or in the culms of grasses." Cameron (6) reports that *T. tepidariorum* Warburton attacks a fern, *T. fragariae* Zimm. is found on strawberries, *T. kirchneri* Kramer, occupies galls of *Eriophyes* (a genus of gall-producing mites), *T. buxi* Canestrinii and Berlese lives in the buds of box, and *T. oryzae* Targioni-Tozetta is an enemy of rice in Italy. *T. anenas* Tryon is said to be a forerunner of the disease of pineapples known as "fruitlet core rot" in Queensland. *T. canestrinii* Marchal produces small galls on several European grasses, such as *Triticum repens*. *T. spirifex* Marchal produces elongate swellings on oats. These distortions of the plant

hosts, characteristically produced by members of the genus *Tarsonemus,* usually serve as protective coverings for the mites. The cyclamen mite is by no means an exception to this rule.

Very small cyclamen seedlings may serve as hosts to cyclamen mites. When heavily infested leaves and flowers are placed on the soil near growing seedlings the mites, deprived of food by drying of the infested leaves, seek food and shelter on the young plants. The cyclamen is peculiar in that at germination the corm begins to develop before the leaves. Mites are attracted to newly sprouted seeds, in two cases two larval mites being observed on the surface of corms about one-eighth inch in diameter, the leaves not having started. Another, older seedling, the first two leaves of which had been killed, bore one female and two resting individuals on the third and fourth leaves. One of the leaves was characteristically distorted.

A single seedling leaf with an area of about one-sixth of a square inch was observed at another time to bear at least fifty larvae and about ten females. The leaf died, probably because of the mite attack.

Tables 1 and 2, based on the examination of older leaves and buds of blooming plants, show the relation of size of bud or leaf to the extent of infestation.

Table 1

Relation of Size of Cyclamen Buds to Extent of Infestation by Cyclamen Mite

Buds were picked at random from infested plants.

Size of bud		No. of mites					Bud injury	Plant injury
Length, in.*	Diameter, in.*	Males	Females	Eggs	Larvae	Resting stages		
0.08	0.06	0	3	10	0	0	None	Severe
.16	.12	0	0	1	0	1	None	Severe
.24	.23	1	32	25	9	15	Severe	Severe
.39	.39	†	..	..	..	..	Severe	Severe
0.39	0.35	†	..	..	..	..	Severe	Severe

* Measurements, originally made in metric units, have been given in English equivalents for the convenience of the average reader.

† 50 or more mites; not all counted.

It will be noted that the buds bear more mites than the leaves and appear to be the most important breeding places. It is rare to find the larger leaves infested, usually only when they have been infested from the beginning, as shown by extensive distortion. It is difficult, if not impossible, to establish mites on older healthy leaves.

Table 2

Relation of Size of Cyclamen Leaves to Extent of Infestation by Cyclamen Mite

Leaves were picked at random from infested plants.

Length, in.*	No. of mites					Leaf injury	Plant injury
	Males	Females	Eggs	Larvae	Resting stages		
0.07	0	0	0	0	0	None	?
.07	0	0	0	0	0	None	Slight
.16	1	0	12	0	1	Severe	Severe
.18	2	0	11	0	0	Severe	Severe
.20	2	0	1	1	0	None	?
.24	2	0	10	2	1	?	Slight
.31	1	1	5	0	1	None	Severe
.31	4	0	3	0	0	None	Severe
.47	5	0	4	2	2	Severe	Severe
0.67	3	0	0	1	0	Severe	Severe
1.42	0	0	0	0	0	Severe	Severe
1.81	0	0	0	0	0	Severe	Severe

* Measurements, originally made in metric units, have been given in English equivalents for the convenience of the average reader.

Spread of Mites

Altho it seems unlikely that seeds are of any great importance in the spread of mites, they sometimes bear these pests on them. A packet of twenty-five seeds, purchased from a seed store, contained six living female mites. A lot of a thousand seeds from another source contained no mites. It is within the limits of possibility that mites transmitted on seeds could live in the soil until germination takes place.

It is a common practice for greenhouse men to transplant cyclamens into a mixture of leaf mold and bog peat. If the cyclamen mite can live outdoors on linden (basswood) and strawberry, it might occur in leaf mold. A careful examination of this material, however, did not disclose any mites of this species.

Mites have been found on sow-bugs by Mr. Parten. Sow-bugs seem to have a particular liking for the cyclamen. The writer has seen large numbers of them sometimes crawling on the leaves. This may be a source of mite infestation in the greenhouse, in which case the extermination of sow-bugs would reduce mite infestation.

It is certain that mites can be carried from one place to another on infested plants. There are about twenty host plants, most of which are common in greenhouses.

Within the greenhouse, crawling is undoubtedly the usual means of spread, altho the rate is very slow. Measurements of distance travelled were, in three cases, 11.4 inches in 38.5 minutes, 12.6 inches in 25 minutes, and 42.5 inches in 77 minutes. The respective rates of travel were 0.30, 0.50, and 0.55 inch a minute, an average rate of 0.47 inch.

The cyclamen mite usually shuns the light and under certain conditions is negatively geotropic, that is, climbs against gravity.

CONTROL

In devising a control for the cyclamen mite one has difficulties to overcome. The reproductive potential is comparatively high. The protective potential is also high; that is, wherever the mites are breeding the plant is curled protectively around them. In addition to the protection of the plant environment, the mites themselves are peculiarly resistant to killing agents.

Tarsonemus pallidus seems to have no natural enemies. The spraying and fumigating to which greenhouse plants are continually subjected would not give biological control a chance to operate. Altho there are no such records for the cyclamen mite, a few other related species are known to be devoured by enemies. Ewing (11) reports that *T. approximatus* Banks is frequently accompanied by a predaceous Gamasid mite. Hodson (17) has observed a Gamasid enemy also of *Rhizoglyphus echinopus* Fumouze and Robin, the bulb mite.

Warburton (27) says, in discussing *Tarsonemus tepidariorum,* that all the usual insecticides have been tried without effect. Carbon disulfide and hydrocyanic acid gas are ineffective. The same statement seems to hold true for the cyclamen mite. The usual recommendation is to spray the plants every ten days with nicotine. Weigel and Sasscer (28) recommend burning infested plants. They conclude that fumigation is not effective.

The various types of control measures that have been suggested for the species of *Tarsonemus* and related mites are dusts, fumigants, dips, sprays, and cultural methods.

Cultural Methods

New plants should be set in a mite-free greenhouse. It is obvious that if uninfested cyclamens are planted near or among infested ones they will soon be infested. On the other hand, if clean plants are placed in a house that has been thoroly cleaned by fumigation or sterilization, the danger of infestation is reduced to a minimum. It is not advisable to grow the other hosts of the mite in the same room with the cyclamens, as it is difficult for the inexperienced eye to detect a mite infestation on such plants as begonia, petunia, and African violet. A frequent inspection of the greenhouse by an expert would go a long way toward eliminating the financial loss incurred by the cyclamen mite.

Cyclamen seeds should be examined for mites before being planted. If they are infested, treatment with warm water (115° Fahrenheit) for

five minutes probably would not injure the seeds materially and would rid them of mites.

Proper spacing of potted plants should prevent some migration of mites from plant to plant.

The best method of controlling the peach bud mite, *Tarsonemus waitei,* consists in pruning lateral buds and shoots (23). Two purposes are served—the mite population is reduced, and, still more important, growth of the central bud is accelerated. This growth is often more rapid than the extension of mite injury. White Rock snapdragons, under favorable conditions, have been observed to out-distance mites. When growth is slow, infestation is usually more severe.

Cameron (6) says, "Too great an amount of nitrogen in the manure is apt to produce an abundance of luxuriant green foliage, which is rather rank, and has not the same resistance to insect and fungus diseases as has the foliage produced under the best conditions. Therefore, nitrogenous manures should be used with caution."

"It has been shown by Andrews . . . that the relation of the available potash to the available phosphoric acid in the soil is important and that, when the amount of available potash in the soil is increased the effect is that plants are less susceptible to injury by pests."

Individual plants are sometimes not infested by mites. There is a possibility that they are mite-resistant, tho it is more probable that they are not sufficiently exposed to attack.

Rotation of crops within the greenhouse has been suggested as a means of reducing mite infestation.

Use of Sulfur

Sulfur has been long recognized as a specific against mites under certain conditions. It is effective against the cyclamen mite when it comes in contact with the organism. To bring the sulfur into actual contact with the mites is a considerable problem, for they are usually well protected by curled leaves and by bud scales. Cameron (6) had little success with sulfur in the control of *Tarsonemus tepidariorum.* Weinard *et al.* (29) mention a mixture of sulfur and naphthalene dust as a promising control for the cyclamen mite. In the present study "Kolo-Dust" (a bentonite-sulfur dust) was not only ineffective against the mites but injured the cyclamens, especially in the presence of moisture. Coarser dusting sulfur seems not to be so rapid in injuring the plants, but growers are of the opinion that it is definitely injurious. The smaller buds appear to be stunted, or blasted. Cameron (6) states that colloidal sulful (2 per cent) with 3 per cent soap, diluted at the rate of 1 to 100, was without effect on the fern mite. The addition of 10

per cent dichlorobenzene, he says, produced a mixture that was ineffective. He found that both "green sulfur" and ammonium polysulfide injured the plants. Dry lime-sulfur has been used by some workers with effect on delphinium that was infested with cyclamen mites outdoors.

Fumigation

The effectiveness of naphthalene in killing red spider has been shown by T. Parker (22) and others. Hartzell (16) has investigated the tolerance of large numbers of plants to naphthalene vapor. The cyclamen plant was not included in his experiments. High relative humidity increases the effectiveness of naphthalene vapor. Weinard *et al.* (29) state that pure naphthalene is of value when dusted on plants. Fumigations with naphthalene, performed by the writer, showed that the plants were fully as susceptible to the vapor as many of the mites. A single potted cyclamen plant was used in each experiment. The mites were enclosed in unopened buds. Table 3 gives the results of the experiments with naphthalene vapor. They show that naphthalene is *not* effective.

Table 3
Result of Naphthalene Fumigation of Cyclamens in Metal Chamber, Capacity, 20.8 cu. ft.
Relative humidity high.

Time	Concentration, gm.	Temperature, ° F.	Mortality of mites	Effect on plant	Remarks
3 hr.	?	75-77	None	None	Naphthalene covering bottom of shallow dish 18 inches in diameter.
16 hr. 30 min.	40	75	Many killed	Slight	Naphthalene melted but very little vaporized.
17 hr.	3	59	Many killed	Severe	Naphthalene entirely vaporized over heat.
16 hr.	15	77	Slight	Severe	Naphthalene scattered in chamber.
24 hr.	?	..	Complete	Severe	Naphthalene covered bottom of shallow dish 18 inches in diameter.
22 hr. 45 min.	5	63-70	No infestation	Severe	Naphthalene completely vaporized over heat.
3 hr.	1	75	Slight	None	Same.
16 hr. 30 min.	0.75	68-77	None	None	Same.

The results of fumigation with paradichlorobenzene, shown in Table 4, are no more promising than those with naphthalene.

Mites exposed to high concentrations of furfural vapor are killed within a few seconds. Furfural, however, is not an effective fumigant.

Table 4

Results of Paradichlorobenzene Fumigation of Cyclamens in Metal Chamber, Capacity, 20.8 cu. ft.

One cup of crystals exposed in a pan in each experiment.

Time	Concentration, gm.	Temperature, ° F.	Mortality of mites	Effect on plant	Remarks
2 hr.	59	Low	No infestation	Severe	
15 hr. 30 min.	59	High	None	Slight	
24 hr.	59	High	Complete	Severe	
15 hr.	66-68	High	No infestation	Moderate	

Table 5

Results of Furfural Fumigation of Cyclamens in Metal Chamber Capacity, 20.8 cu. ft.

Time	Furfural concentration, cc.	Temperature, ° F.	Humidity	Mortality of mites	Effect on plant	Remarks
14 hr. 30 min.	1	61	High	None	None	Cold furfural on blotter in all experiments except as noted.
45 hr. 30 min.	1	61-73	High	Complete	Severe	
8 hr.	3	64	High	Incomplete	Severe	3 adults survived.
11 hr.	4	64	High	Complete	Severe	Fan circulation for short time.
9 hr.	5	64-68	High	Complete	Severe	
20 hr.	6	59	High	Complete	Severe	
25 min.	10	61	Low	Slight	Severe	
10 min.	20	..	Low	Slight	Severe	Furfural vaporized by heat.
5 hr. 30 min.	20	64-65	High	Slight	Severe	Only mites on stamens were killed.

Preliminary trials with pure nicotine showed that mites exposed to its fumes in a small space were quickly paralyzed and killed. Nicotine sulfate, activated by the addition of soap and sprayed on plants in a tight metal chamber, killed none of the mites. A newly mixed 5 per cent nicotine dust had no effect when used in the same chamber. Both experiments were performed at 75° Fahrenheit and with high relative humidity. Dusting was accomplished by connecting a duster to the closed chamber by rubber hose. The thoroness of dusting was observed through a glass window in the chamber. In another experiment, about 20 cubic centimeters of nicotine sulfate was vaporized on a hot plate in the chamber. After ten hours no mites had been killed.

Experiments with formaldehyde showed that mites are very susceptible to its vapor. Mites exposed to a high concentration for about three minutes seemed to have difficulty in raising their feet from a clean glass

slide and death followed in a few minutes. An infested plant was exposed to the vapor of 50 cc. of the 40 per cent formaldehyde at a temperature of 68° and low relative humidity. The plant was severely bleached and no mites were killed.

Preliminary tests of pyridine as a fumigant show some promise. Snapdragons, however, are rather susceptible to this compound. Mites are very quickly paralyzed by it. Jewson and Tattersfield (18) used pyridine to rid fungus cultures of mites. They also mention that ammonia has a high toxicity for mites.

It seems impossible completely to kill mites with cyanide without injuring cyclamens. The results of numerous tests are given in Tables 6 and 7. It was hoped that a concentration-time correlation could be found where the mites would be killed and the plants still be uninjured. If there is any margin of safety here it appears to be insignificant.

Table 6

Results of Fumigation of Cyclamens with Calcium Cyanide in Wooden Box, 19 cu. ft. Capacity

Time, hr.	Amount of cyanide, gr.	Temperature, ° F.	Humidity	Mortality of mites	Effect on plant	Remarks
15	0.07	..	High	None	None	
15	0.14	..	High	None	None	
17	1.0	56	High	None	None	
16	3.0	60	High	None	None	Mites all revived.
21	3.0	64	High	None	None	Eggs of mites were not killed.
22.5	6.0	55-63	High	None	None	
20.5	10.0	62-63	High	Slight	Moderate	
18.5	25.0	61-63	High	Incomplete	Severe	

In connection with cyanide fumigation it is interesting to note that Brinley and Baker (3) were able to increase the kill of grain weevils from 59 to 77.4 per cent by the addition of methyl acetate. They supposed that the acetate served to stimulate respiratory activity in the insects. Carbon dioxide is sometimes used for the same purpose. It is possible that the combination of one of these compounds with cyanide might allow the necessary margin of safety for fumigation of the cyclamen mite on host plants.

Table 7
Results of Fumigation of Cyclamens with Sodium Cyanide in Metal Chamber, Capacity, 20.8 cu. ft.

Time	Amount of cyanide, gr.	Temperature, ° F.	Humidity	Mortality of mites	Effect on plant	Remarks
18 hr. 45 min.	1.0	52-61	High	None	Severe	
1 hr. 45 min.	1.3	..	Low	None	None	
5 hr.	2.0	..	Low		Severe	
1 hr. 50 min.	2.5	55-58	Low	None	None	Plant died of unknown cause.
3 hr. 15 min.	2.5	..	Low	Slight	Slight	
2 hr. 45 min.	2.75	55-63	Low	High	Severe	Fan circulation of gas.
3 hr. 15 min.	2.75	70	High	Slight	None	
3 hr. 15 min.	2.75	..	Low	Complete	Severe	Previous sulfur treatment.
3 hr. 30 min.	2.78	64	Low	Complete	Moderate	Old leaves alive and young leaves started.
3 hr.	2.85	55	Low	Nearly comp.	None	One female mite survived.
2 hr. 50 min.	2.98	63	Low	Complete	Severe	
1 hr. 50 min.	3.01	63-66	Low	None	None	
3 hr. 10 min.	3.01	63	Low	Complete	Moderate	
2 hr. 8 min.	3.17	..	Low	Complete	Severe	
2 hr. 7 min.	3.25	52	Low		Severe	Fan circulation.
3 hr.	3.27	59-63	High	None	None	
2 hr. 30 min.	3.3	..	Low		Severe	
12 hr.	3.36	..	Low	Complete	Severe	
1 hr. 30 min.	3.5	52	Low	Slight	Severe	Fan circulation.
2 hr. 40 min.	3.5	..	Low	Complete	Severe	
2 hr. 45 min.	3.65	61	Low	Complete	Severe	New leaves started.
2 hr. 10 min.	3.7	..	Low	Complete	Severe	
1 hr.	3.91	52	Low		Severe	New leaves started.
4 hr.	4.0	64	High	Complete	Severe	
7 hr. 13 min.	5.4	66	High	Complete	Severe	
5 hr. 40 min.	5.5	68	High	Complete	Severe	
30 min.	10.0	..	Low	Nearly comp.	Severe	One female recovered.
30 min.	13.25	..	Low	Complete	Severe	
23 hr. 30 min.	13.83	57-61	Low	Complete	Severe	
1 hr. 30 min.	19.53	61	Low	None	Severe	
20 hr.	25.0	55-63	Low	Complete	Severe	Corm dead within 6 weeks.
1 hr.	27.2	..	Low	Complete	Severe	
3 hr. 30 min.	27.7	64	Low	Complete	Severe	
50 hr.	49.0	54-61	Low	Complete	Severe	Corm dead within 6 weeks.

Sprays

Nicotine contact sprays have been stated as effective in mite control. The normal situation of mites in protected locations, however, makes such sprays ineffective because of their inability to spread into chinks and crevices in the plants. Trials with nicotine-soap and nicotine-Vlock sprays on snapdragons and fuchsias showed little or no effect on mites. It is not to be denied, however, that florists who use nicotine sprays on cyclamen at regular weekly intervals have plants almost entirely free from mites. It has been said that nicotine, used over an extended period, is repellent to mites.

A 75 per cent kill of *Tarsonemus fragariae* has been reported from the use of a one per cent formalin solution outdoors.

Kerosene emulsions have been recommended for the last mentioned mite and also for the peach bud mite (23). "Fir-tree oil" spray or nicotine sulfate is said by Britton *et al.* (4) to be particularly effective in controlling the cyclamen mite on snapdragons. Volck is said to have a stunting effect on plant growth when applications are made too frequently.

Gossard (15) advises spraying with a stream of pure water in order to dislodge mites. Some cyclamen growers maintain that frequent washing with water will give good control if followed with care.

Hot Water Treatment

When H. Garman (13) discussed the newly discovered and yet unnamed mite from Illinois verbenas in 1883, he suggested treatment with hot water as a control. "They are killed by hot water at a temperature of one hundred and twenty (120) degrees Fahr. The plants may be safely immersed in such water for a half minute, and as this is practicable with potted plants, a means of cure is accessible to all."

Moznette (21) says, "As heat is very penetrating it occurred to the writer that possibly it could be used against this mite, but it was found that the plants could not be subjected to sufficient heat to kill the mites." Cameron (6) in connection with controlling the fern mite, suggested the possibility of treating the fern "pips" with heat before planting them. "But it is probable that they would not stand that." Both Moznette and Cameron apparently had dry heat in mind.

Hot water has been suggested for insect control by several workers. It is a simple and efficient remedy for house-plant insects. Van Slogteren (26) was the first (1920) to use hot water successfully in controlling narcissus nematodes. He applied water at a temperature of 110° for three hours. Doucette (7), in 1926, found a temperature of 110° for 2½ to 3 hours is sufficient to kill *Rhizoglyphus hyacinthi* Bdv.

(bulb mite), *Merodon equestris* Fab. (Narcissus bulb fly), *Eumerus strigatus* Fallen (lesser bulb fly), and the nematode, *Tylenchus dipsaci* Kuhn.

Doucette (8), in 1929, reports that an immersion of narcissus bulbs for half an hour at 110° is sufficient to kill *Tarsonemus approximatus* infesting these bulbs. Smith *et al.* (25) have investigated the practicability of immersing in hot water for control of the boxwood leaf miner. They obtained complete control with a temperature of 120° for 5 to 10 minutes. There is danger of bleaching the leaves if they are not shaded for a few days. Fleming and Baker (12), in investigations of the control of the Japanese beetle, found that about twenty species of potted plants could stand immersion in water at 112° for 70 minutes. None of these plants, however, has been recorded as host of the cyclamen mite.

Brues (5) says that temperatures required to kill plants are in general higher than those required to kill animals.

The use of hot water seems to have been investigated very little as a practical control for tarsonemid mites on potted greenhouse plants. Cultural methods for the plants that are most susceptible to the attacks of the cyclamen mite lend themselves very well to the use of this control. While the mites are well protected from chemicals in sprays and gases, they are usually located on small, thin leaves and buds which are quickly heated through in warm water. Most of the affected plants are grown in pots so they can be placed on racks for immersion right side up without any other preparation.

Table 8 gives the results of numerous treatments of different greenhouse plants with hot water.

Table 8

Results of Hot-Water Treatment of Greenhouse Plants for Control of Cyclamen Mite

The cyclamens used in these experiments, except when otherwise noted, were young ones in 3-inch pots.

Plant	Time, min.	Temperature, ° F.	Mortality of mites	Effect on plant	Remarks
1 Cyclamen	¼	124	No infestation	None	
1 Begonia	½	118	No infestation	None	
1 Fuchsia	½	120	No infestation	Slight	
1 Begonia	½	123	One present was killed	Moderate	
1 Begonia	½	126	No infestation	Slight	
1 Petunia	½	126	No infestation	Slight	
1 Coleus	1	117	No infestation	None	
1 Petunia	1	117	No infestation	None	
1 Fuchsia	1	118	No infestation	None	
1 Fuchsia	1	118	Two present were killed	None	
1 Petunia	1	120-121	Incomplete	Slight	One live mite, but many dead.
1 Petunia	1	120-121	One present was killed	None	

Table 8—Continued

Results of Hot-Water Treatment of Greenhouse Plants for Control of Cyclamen Mite

The cyclamens used in these experiments, except when otherwise noted, were young ones in 3-inch pots.

Plant	Time, min.	Temperature, ° F.	Mortality of mites	Effect on plant	Remarks
1 Begonia	1	121	No infestation	None	
1 Fuchsia	1	119	No infestation	None	
1 Begonia	1	122	One present was killed	None	
1 Cyclamen	1	122	No infestation	None	
1 Petunia	1	122	Incomplete	Slight	Several still alive altho many killed.
1 Cyclamen	1	124	No infestation	None	
1 Petunia	1	124	No infestation	Moderate	
1 Cyclamen	1	124	No infestation	Slight	
1 Petunia	1	123	Slight	Slight	
1 Cyclamen	1½	117	No infestation	None	
1 Cyclamen	1½	117	No infestation	None	
1 Cyclamen	1½	115-117	No infestation	None	
2 Snapdragons	1½	118	No infestation	None	
1 Cyclamen	1½	118	No infestation	None	
2 Snapdragons	1½	119	No infestation	None	
1 Snapdragon	1¾	118	No infestation	None	
7 Begonias	1¾	117	Complete	Slight	Not shaded after treatment.
2 Begonias	2	117	Complete	Very slight	Not shaded after treatment.
1 Petunia	2	117	No infestation	Very slight	Not shaded after treatment.
1 Cyclamen	2	117	No infestation	None	Not shaded after treatment.
1 Cyclamen	2	117	One still alive	None	Not shaded after treatment.
1 Begonia	2	117	Complete	None	Not shaded after treatment.
56 Begonias	2	117	Complete	None	Shaded for one day.
2 Begonias	3	117	Complete	Slight	Shaded for one day.
1 Begonia	3	117	No infestation	Slight	Not shaded; some bleaching on south side.
1 Fuchsia	3	114	50 per cent	None	Not shaded.
1 Fuchsia	3	115	Complete	None	
1 Snapdragon	3	124	No infestation	Severe	
1 Snapdragon	3½	122	No infestation	Severe	
1 Petunia	3½	124	No infestation	Severe	
1 Fuchsia	4	112	Incomplete	None	Not shaded.
8 Begonias	4	115	Complete	None	Shaded for one day.
3 Snapdragons	4	115	No infestation	None	
1 Cyclamen	4	115	No infestation	None	
4 Cyclamens	4	115	No infestation	None	
1 Cyclamen	4	115	Nearly complete	None	All, including eggs, dead except one larva alive.
1 Snapdragon	4	120	No infestation	Severe	Shaded.
5 Begonias	5	113	Incomplete	None	Not shaded.
3 Begonias	5	115	Complete	Slight bleaching	Not shaded.
1 Fuchsia	5	113	Complete	None	Not shaded.
1 Chrysanthemum	5	115	No infestation	Very slight	
100 Chrysanthemums	5 to 6	113-115	Complete	Very slight	Completely recovered six weeks after treatment.
6 Fuchsias	6	111	Complete	None	Shaded.
125 Cyclamens	5	115	Complete	*	Plants mature with many buds.
5 Cyclamens	6	115	No infestation	None	Shaded.

* Flower buds severely injured four weeks after treatment.

These results indicate that the temperature and the time recommended by H. Garman in 1883, *i.e.,* 120° for a half minute, are not sufficient to control the mite on most plants. One minute at this temperature did not give complete control on petunia.

By controlling the temperature and time of treatment carefully, however, good results may be obtained by the hot-water method. The conditions should be varied, depending upon the kind of plant being treated. Water at a temperature of from 113° to 115° for from 5 to 6 minutes is effective in the case of fuchsia and chrysanthemum without injury to the plant. Cyclamens which have not yet begun to put out flower buds can stand 115° for five minutes. The hot water treatment is not recommended for use on older cyclamens. Water at 115° for five minutes will injure the flower buds on the older plants. The injury becomes apparent three or four weeks after treatment. Begonias can be freed of mites by treating at a temperature of 116.5° for two minutes. It is advisable to shade the plants for a day or two after treatment to prevent injury by direct daylight.

SUMMARY

The cyclamen mite is common all over Minnesota in greenhouses in which its food plants are grown. Altho cyclamen is a favorite host, the mite is destructive on a variety of plants. The presence of the mite is manifested by the appearance of characteristically distorted leaves. Since the youngest leaves and buds are attacked first it is difficult to detect the early stages of an infestation. Frequent and thoro inspection of the greenhouse by an entomologist is therefore recommended.

Sprays and fumigants are not effective in ridding infested plants of the mites, altho some workers report that the repellent effect of frequent nicotine sprays is sufficient to give good control.

Hot water treatment appears to be the only method available for eradicating the mites from infested plants. Good results can be obtained by this method if the time and temperature are carefully regulated. The flower buds of older cyclamen plants can not stand the hot water treatment.

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